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भाग 1 इस्पात फ्रेम वाले

Indian Standard

BIOGAS PLANTS — GLASS FIBRE REINFORCED POLYESTER RESIN GAS HOLDERS — SPECIFICATION

PART 1 WITH STEEL FRAME

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

March 1991 **Price Group 4**

Chemical Engineering Plants and Related Equipment Sectional Committee, HMD 17

FOREWORD

This Indian Standard (Part 1) was adopted by the Bureau of Indian Standards on 22 June 1990, after the draft finalized by the Chemical Engineering Plants and Related Equipment Sectional Committee had been approved by the Heavy Mechanical Engineering Division Council.

This standard (Part 1) deals with the quality, performance, requirements and overall dimensions, methods of test for glass fibre reinforced unsaturated polyester resin biogas holders for family size biogas plants.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

BIOGAS PLANTS — GLASS FIBRE REINFORCED POLYESTER RESIN GAS HOLDERS — SPECIFICATION

PART 1 WITH STEEL FRAME

1 SCOPE

1.1 This Indian Standard (Part 1) specifies the requirements for contact moulded glass fibre reinforced polyester resin biogas holders with steel frame suitable for floating drum type biogas plants.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
1998 : 1962	Method of test for thermosetting synthetic resin bonded laminated sheets
6746 : 1972	Specification for unsaturated polyester resin system for low pressure fibre reinforced plastics
9478 : 1986	Specification for biogas plants
11273 : 1985	Specification for woven roving fabric of 'E' glass fibre
11320 : 1985	Specification for glass fibre rovings for the reinforcement of polyester and epoxide resin systems
11551 : 1986	Specification for glass fibre chopped strand mat for reinforcement of polyester resin systems

3 TERMINOLOGY

3.0 For the purpose of this standard the following definitions shall apply.

3.1 Wrinkles

Surface imperfections caused by solvent attachment on the polyester resin coat due to undercuring of the resin.

3.2 Pinholes

Small air bubbles which are trapped in the first coat of resin before gelation.

3.3 Blistering

Surface imperfection due to entrapment of air or solvent.

3.4 Fish-Eyes

Round patches of pale colour due to imperfect wetting.

3.5 Crazing

Fine hair cracks on the surface.

3.6 Leaching

Exposure of glass fibres on laminate.

3.7 Star Cracking

Surface cracking of resin.

3.8 Striations

Improper mixing of pigment.

3.9 Chalking

Chalk-like appearance on the surface.

3.10 Impurities

Foreign matter present.

3.11 Defective Impregnation

Imperfect impregnation of glass fibre with unsaturated polyester resin.

3.12 Traces of Mending

Traces left over after mending is carried out to eliminate small defects.

3.13 Aggregate Defects

This term is used when pinholes, blisters, impurities and traces of mending are present at the rate of 5 each or more than 5 in aggregate for all defects.

3.14 Gas Holder

It is storage tank for biogas, which moves up and down above the digester, on a central guide pipe situated in the centre of the digester. The gas outlet is at the top of gas holder.

3.15 Biogas

It is a gaseous mixture containing about 60 percent methane, a high value fuel, about 40 percent carbon-dioxide and traces of other gases such as ammonia and hydrogen sulphide obtained from anaerobic fermentation of bio-mass.

3.16 Bio-Mass

This refers to bio-degradable material originating in land and aquatic environments. Cowdung is one of the most important and widely used of bio-mass for the production of biogas. The dung may be supplemented with other materials like night soil, poultry droppings and excreta of other livestock.

3.17 Anaerobic Fermentation

The biological conversion process carried out by micro-organisms which convert bio-mass, in the absence of oxygen, to methane.

3.18 Size/Rated Capacity

The rated capacity of bio-gas plants is the approximate daily output of the gas in cubic metres which is produced by the bio-gas plant (*see* IS 9478 : 1986) when fed with prescribed quantity of bio-mass.

3.19 Cylindrical Height

This relates to the vertical height from the base of the gas holder to the joint where the slope changes that is where the conical portion commences. (Represented as '*F*' in Fig. 1).

3.20 Conical Height

This relates to the proof section of the gas holder and its vertical height from the apex (top) of the holder to the point where the slope changes at the start of the height of cylindrical portion. (Represented as '*E*' in Fig. 1).

3.21 Flange Height

This relates to the extended portion of the cylindrical height of the gas holder that is additional height from the junction of the conical and cylindrical portion. (Represented as '*H*' in Fig. 1). This is required as a support for additional dead load (sand bags/bricks) to be placed on the roof of the gas holder.

3.22 Dead Load

This relates to the additional mass (in the form of sand bags, bricks or other similar material) which is placed on the roof of the gas holder to compensate for the difference in mass required to generate the pressure of 10 cm to 15 cm of water column.

3.23 Surfacing Veil

A light weight, non-woven fabric based on glass or polyester fibre of density 30 g/m^2 to 50 g/m^2 for use as the back-up layer immediately after the gel coat in the moulding sequence.

4 MATERIALS

The materials to be used for moulding the biogas holders shall be composed of unsaturated thermosetting polyester reinforced with glass fibres. This system must include black pigments (compatible with polyester resin), curing agents, catalysts and ultraviolet stabilisers. No fillers shall be used in the moulding of the gas holders.

4.1 Glass Fibre

The glass fibre reinforcements used shall be of type 'E' glass such as:

a) Glass fibre chopped strand mat specified in IS 11551 : 1986.

b) Glass fibre woven rovings specified in IS 11273 : 1985.

c) Glass fibre rovings specified in IS 11320 : 1985.

4.2 Polyester Resin

Isophthalic grade unsaturated polyster resin shall be used in the manufacture of the biogas holders. The properties of the resin shall conform to the values given in Table 1 and the methods of test shall comply with that given in IS 6746 : 1972.

Table 1 Typical Properties of Isophthalic Unsaturated Polyester Resin

Property	Value	Method of Test
Acid Value (mg KOH/g)	10 to 20	IS 6746 : 1972
Volatiles (%)	40	IS 6746 : 1972
Specific Gravity (25/25°C)	1·11	IS 6746 : 1972

4.3 Pigment

Black pigment (colouring material) compatible with polyester resin shall be used in the moulding of the holders. The concentration of pigment shall be such as to provide a uniform colour to the moulded gas holder. In any case, the concentration of the pigment shall be not less than 5 percent by mass of the resin.

4.4 Gel Coat

The use of gel coat on the outside exposed surface of the moulded biogas holder is necessary. It should be isophthalic acid based unsaturated polyester resin in accordance with **10.6**.

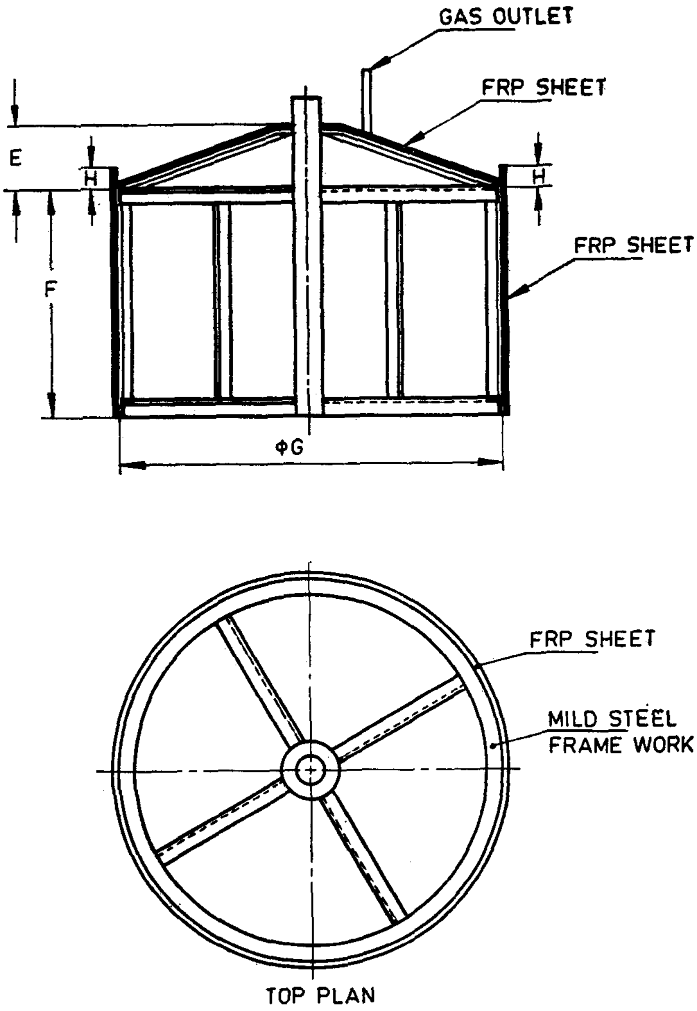
4.5 Surfacing Veil

A non-woven surfacing veil based on glass or polyester fibre having a density of 30 to 50 g/m^2 may be incorporated immediately after the gel coat in the moulding sequence.

5 DESIGN AND CONSTRUCTION FEATURES

5.1 The gas holder consists of a mild steel skeletal frame work which is covered with a fibre glass reinforced polyester resin cap on the conical (roof) and cylindrical portions. The dimensions of the mild steel frame work shall conform to the requirements given in IS 9478 : 1986.

5.2 The overall dimensions of the gas holders shall be as given in Fig. 1.



Capacity	(m³)	1	2	3	4	6	8	10
Diameter '*G*' (Tolerance ± 0·5)	(cm)	108	118·4	145	167	205	211·8	236·7
Height '*F*' (Tolerance ± 0·5)	(cm)	60	100	100	100	100	125	125
Slope '*E*' (Tolerance ± 0·5)	(cm)	5	5	10	10	15	15	15
Moulded flange height '*H*' (Minimum)	(cm)	3	5	5	5	7·5	7·5	7·5
Moulded flange thickness (Minimum)	(cm)	0·28	0·28	0·28	0·28	0·28	0·28	0·28
Thickness of moulded sections (Minimum)								
— Cylindrical portion	(cm)	0·22	0·22	0·22	0·22	0·22	0·22	0·3
— Conical/Roof portion	(cm)	0·28	0·28	0·28	0·28	0·28	0·28	0·3

FIG. 1 GAS HOLDER (MILD STEEL FRAME WORK) COVERED WITH FIBRE GLASS DOME

6 METHOD OF FABRICATION

6.1 The gas holders shall be fabricated by contact moulding so as to result in a surface having a smooth exterior finish and a resin-rich surface on the interior of the holder. Any other method of moulding that results in a smooth finish in the interior portion, may also be adopted. The exposed exterior surface shall consist of gelcoat and/or surfacing veil and shall be devoid of the presence of any exposed glass fibres. The gas holders shall also be fabricated in such a manner that the final product may be extracted as a single piece (by use of a mould) or formed from two sections made separately and comprising of conical (roof) and cylindrical (vertical) portion which are subsequently joined after fitment to the steel frame work. When a mould is used; the moulded holder, after release, is made to slide over the steel frame work. In case the gas holder is made in two sections and then joined (after fitment over the steel frame work), the junction of the cylindrical and conical portions shall be properly sealed with fibre glass and isophthalic unsaturated polyester resin to ensure that there will not be any leakage of gas when the holder is in operation.

7 WORKMANSHIP AND FINISH

7.1 The moulded gas holder shall be free from cracks, craze, wrinkles, pinholes, blisters, chip areas and other manufacturing defects that may affect their appearance and performance. The interior steel sections of the frame work of the gas holder shall be given a coating of isophthalic unsaturated polyester resin to retard corrosion. All joints shall be properly sealed with glass fibre and resin to ensure that no leakage of gas occurs. The flange that is built around the circumference of the gas holder (for placing the dead load) shall have a thickness and height as specified in Fig. 1. Holes may be drilled at 4 or 5 locations in the flange (vertical section) along the circumference to facilitate drainage of rain water that may possibly accumulate. As the moulded holder is fitted over the steel frame work; it shall also be necessary to lap the internal vertical and lateral sections of the mild steel frame work and the moulded holder with fibre glass chopped strand mat so that the moulded holder is held firmly against the steel frame work.

7.1.1 The defects that shall not be permitted on the exterior portion of the gas holder are as follows:

a) Small pores/pinholes,
b) Crazing,
c) Blistering,
d) Defective impregnation,
e) Superficial defects/damage,
f) Wrinkling, and
g) Aggregate defects.

7.1.2 The permissible range of various defects on the exterior portion shall be as given in Table 2.

Table 2 List of Permissible Defects

Sl No.	Defects	Visible Parts
i)	Colour blots/Striations	Shall not be conspicuous
ii)	Unevenness	,, ,,
iii)	Traces of mending	,, ,,
iv)	Impurities	,, ,,

7.2 The gas holders shall be installed at site only after seven days of curing under normal atmospheric conditions.

8 ACCESSORIES

8.1 Fittings

Each fabricated gas holder shall be provided with the following:

a) Gas outlet, and
b) Eyelets (drilled holes) in the additional flange height provided on the circumference of the gas holder to serve as provision for lifting the gas holder.

8.2 Gas Outlet

8.2.1 The flange for the gas outlet shall also be made in glass fibre reinforced unsaturated polyester resin. The diameter of the gas outlet shall be in accordance with the details given in Fig. 5 of IS 9478 : 1986.

8.2.2 The flange shall be moulded to have a thickness of at least 0·4 to 0·5 cm (4 to 5 mm). A PVC pipe (or any other suitable material) shall be used as the former (diameter of the former corresponds to the diameter of the gas outlet) for the flange pipe. The pipe shall extend into the gas holder to a depth of at least 2·5 cm (25 mm).

8.2.3 To support the moulded flange in position; wooden gussets shall be provided (or any other suitable material) in position and encapsulated with glass fibre reinforcement and unsaturated isophthalic polyester resin.

8.2.4 Bolt holes shall be drilled in the moulded flange for joining to the matching flange of the mild steel bend (mild steel bend details shall be as in Fig. 6 of IS 9478 : 1986). A suitable gasket shall be provided between the steel and moulded flanges to ensure that no leakage of gas takes place after tightening of bolts and nuts. (The presence of any leakage can be checked by the methods outlined in **9.1** and **9.2**). The subsequent connections shall be as that outlined in **8.1** of IS 9478 : 1986.

8.3 Eyelets

Drill three pairs of holes at the additional flange height of the holder, space the holes of each pair at 10 to 12·5 cm (100 to 125 mm). The three pairs of holes shall be spaced so as to form the three vertices of an equilateral triangle (along the circumference). The hole diameter can be 1 to 1·5 cm (10 to 15 mm). Hole centre shall be at a distance of approx 4 cm (40 mm) from the flange top. If necessary, metallic eyelets may be provided for the holes. Pass a thick rope through each pair of holes so as to result in a 'handle' being formed. Lift the holder by using the three 'handles'. (Any other suitable method for lifting the gas holder can also be provided as long as it does not interfere with the stability of the gas holder).

9 TESTS FOR LEAKAGE

Gas holders moulded out of glass fibre reinforced unsaturated polyester resin shall be thoroughly tested for any leakage before release to the field for installation. The following tests shall be carried out to ensure that there is no leakage of gas. The tests shall be carried out after a minimum period of 24 hours has elapsed after the moulding of the gas holder.

9.1 Water Test

The moulded gas holder is inverted with the conical portion facing the ground and made to rest on a steel ring (or any other suitable support). The height of the apex of the cone from the ground shall be at least 100 cm (1 000 mm). This minimum distance is necessary to observe any leakage from the joints. Provision that has been made for the gas outlet shall be plugged to prevent seepage of water. After the holder has thus been made to rest on the steel ring, fill with water up to a height of approximately 7·5 cm (75 mm) above the junction of the cylindrical and conical portion. The leakage of water, if any, at the joints is then observed for a period of 24 hours. If any leak spots are detected, identify immediately by visible chalk markings and cover the points of leakage using glass fibre and resin and repeat the test to ensure that gas leakage has stopped.

9.2 Smoke Test

The gas holder is placed on the ground in its normal position (that is on its base) and the gas outlet closed. Close the periphery of the gas holder at the bottom with gunny or coir bags (or other similar material) and loose sand so as to result in an air-tight compartment to prevent escape of smoke from the bottom. Generate smoke inside the gas holder by use of coir or cotton waste or any other suitable material. (Care should be taken to ensure that the degree of combustion is restricted to generation of smoke alone). Observe the points of leakage, if any, especially at all joints. If any leak spots are detected, identify immediately by visible chalk markings and cover the points of leakage immediately using glass fibre and resin and repeat the test to ensure that gas leakage has stopped.

10 PERFORMANCE REQUIREMENTS

10.1 Samples

The test sample laminates shall be cut from the projections provided as an integral part of the gas holder. The sample shall be cut from a distance of 4 cm (40 mm) away from the edges of the projection. The cut pieces shall be first stabilized at room temperature for 24 hours. The sample shall then be cured at 80°C minimum for three hours. Alternatively, test laminates shall be separately made with the same materials and same lay-up sequence and thickness as that used in the moulding of the gas holder.

10.2 Hardness

The external surface shall show a minimum reading of 40 points on a Barcol impressor or any other suitable apparatus when tested in accordance with the procedure given in Annex A.

10.3 Water Absorption

The water absorption shall not exceed 0·5 percent in 24 hours, when the laminate is tested in accordance with the method given in Annex B.

10.4 Leakage

There shall be no visible leakage when the tank is tested in accordance with the method specified in **9.1** and **9.2.**

10.5 Cracking or Crazing

A test piece taken from any part of the moulded gas holder shall not show, on visual inspection, any sign of cracking or crazing after the oven test given in Annex C.

10.6 Gelcoat

The quantity of gelcoat in moulded gas holders shall be such as to give a coverage of 450-500 g/m². Based on this coverage; the thickness of the gelcoat shall not be less than 0·30 mm or more than 0·5 mm when determined in accordance with the method outlined in Annex D.

10.7 Glass Content

The glass content of the moulded laminate at any point shall not be less than 30 percent by mass when tested in accordance with the procedure given in Annex E.

10.8 Tensile Strength of Laminate

The tensile strength of the moulded laminate at any point shall not be less than 8 kg/mm^2 when tested in accordance with the procedure given in IS 1998 : 1962. The tensile test shall be carried out on a specimen cut out from a section of the moulded gas holder or from a laminate that has been made with the same number of layers (and in the same sequence of lay-up) as has been used in the fabrication of the holder.

10.9 Cross Breaking Strength of Laminates

The cross breaking strength of the moulded laminate at any point shall not be less than 16 kg/mm^2 when tested in accordance with the procedure given in IS 1998 : 1962. The cross breaking strength test shall be carried out on a specimen cut-out from a section of the moulded gas holder or from a laminate that has been made with the same number of layers (and in the same sequence of lay-up) as has been used in the fabrication of the gas holder.

10.10 Impact Resistance

The impact resistance of the moulded gas holder shall be tested in accordance with the procedure laid down in IS 1998 : 1962. The impact test shall be carried out on a specimen cut out from a section of the moulded gas holder or from a laminate that has been made with the same number of layers (and in the same sequence of lay-up) as has been used in the fabrication of the gas holder. The impact resistance shall be not less than 120 j/m.

10.11 Temperature Variation

The moulded water gas holders shall withstand the temperature range of -40° C to $+60^\circ$ C.

10.12 Additional Requirements

All exposed mild steel portions of the gas holder frame work shall be given a coat of isophthalic unsaturated polyester resin.

11 CALCULATION OF DEAD LOAD ON ROOF OF GAS HOLDER

11.1 It is necessary for the gas holder to have a minimum mass in order to deliver the gas at a pressure of 10 cm of water column. Theoretical mass of the fabricated gas holder (including steel frame work) is calculated initially. Roof area of the holder is then computed. The difference in mass of the fabricated gas holder and the total mass of the gas holder required to deliver 10 cm water column pressure will give the additional dead load required to be placed on the roof of the gas holder.

A typical calculation to arrive at the dead load for a gas holder of 6 m^3 capacity is given below:

Gas holder capacity : 6 m^3
Diameter of gas holder : 2 m
Roof area of gas holder : 3·2 m^2
Total mass of gas holder required to deliver 10 cm of water column pressure : $101{\cdot}65 \times 3{\cdot}2 = 326$ kg
Mass of fabricated gas holder : 160 kg (including steel framework)
Hence, additional dead load required on roof of the gas holder : $326 - 160 = 166$ kg

This dead load shall be uniformly distributed on the roof of the gas holder. The dead load shall be in the form of sand bags, bricks or any other equivalent type of material that does not have sharp edges which are likely to cause damage to the surface of the gas holder.

11.2 Typical dead loads for gas holders up to 10 m^3 capacity can be calculated on similar lines and are given in Table 3.

12 MARKING

12.1 Each gas holder shall be marked with the indication of the source of manufacture, month/year of manufacture, capacity of the gas holder (in m^3) and batch number on the roof of the gas holder or in any conspicuous position.

13 CRITERIA FOR CONFORMITY

13.1 Each fabricated gas holder shall be subjected to the leakage tests as outlined in **9.1** and **9.2**.

13.2 The gas holder shall be considered as conforming to the requirements of this specification, if it meets the performance requirements specified in **10** and also passes the tests for leakage specified in **9.1** and **9.2**.

14 HANDLING AND USE OF GLASS FIBRE REINFORCED POLYESTER RESIN GAS HOLDERS

14.1 Some guidelines on handling and use of the moulded gas holders are as follows.

14.2 Do not roll the gas holder on the ground while loading on the vehicle or installing at site. Lift the gas holder manually during loading and installing.

14.3 Do not allow the gas holder to rest on its side (that is horizontal position) in the vehicle during transportation. Keep the holder in a vertical position preferably so that the holder rests on the bottom ring.

Table 3 FRP and Steel Gas Holders — Mass Details

(*Clause* 11.2)

Mass Details	Capacity of Gas Holder in m^3						
	1	2	3	4	6	8	10
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Minimum mass of moulded holder (kg)	15	20	25	30	35	65	80
Nominal mass of mild steel frame (kg)	40	60	80	90	125	140	165
Additional uniformly distributed dead load on roof of moulded holder to maintain pressure of 10 cm of water column (kg)	(40-50)	(80-90)	(110-120)	(120-140)	(160-180)	(200-220)	(320-340)

14.4 Do not handle the gas holder roughly by dropping it on the ground from the vehicle. If rolling is done, use two steel pipes to form an incline from the vehicle on to the ground and roll the holder down slowly.

14.5 Do not allow the gas holder to have impact with the side walls of the vehicle during transportation. Use of cushioning medium (gunny bags, etc) between the gas holder and wall is advisable.

14.6 Do not place dead load on the roof of the gas holder at random. The dead load should be uniformly distributed on the roof of the gas holder on all sides. The use of sand bags is recommended.

14.7 Do not place dead load less than that recommended in the specification sheet. A minimum dead load for each capacity is necessary to enable the gas to be under adequate pressure to press the gas to the points of usage (that is stove or lamp).

14.8 Do not use sharp instruments (screw driver, knife, chisel, etc) during installation of the gas holder. This is to avoid any accidental damage to the gas holder by way of surface chipping or hairline cracks.

14.9 Do not install the gas holder at site immediately after fabrication. It is advisable to allow a minimum period of 7 days to elapse before the gas holder is installed at site. The full strength of the holder can thus be derived.

14.10 Do not install the gas holder without testing for presence of leaks. It is advisable to carry out (a) Water test and (b) Smoke test to ensure that there are no leaks, before release to the field.

ANNEX A

(*Clause* 10.2)

DETERMINATION OF HARDNESS

A-1 PROCEDURE

A-1.1 With the indentor perpendicular to the test surface, a light hand pressure is exerted against the instrument to drive the spring loaded indentor into the material and the hardness dial reading is taken and recorded after a 10 second interval. An average of at least 5 tests shall be used for determining conformity with **10.2.**

ANNEX B

(*Clause* 10.3)

METHOD OF TEST FOR WATER ABSORPTION

B-1 PROCEDURE

B-1.1 Test pieces shall be cut to size 50 mm × 50 mm or area of diameter 30 mm and the exposed edges of the pieces shall be coated with resin to prevent inter-laminar attach. The sections of the pieces shall be cleaned, dried for 24 h in an air bath at 50 ± 3°C and then allowed to cool in a desiccator. Following this, the pieces shall be weighed immediately with the help of a chemical balance. Next, the test pieces are immersed in distilled water for 24 h at 27 ± 2°C; taken out, the water wiped out with a piece of dry cloth and then weighed again immediately.

The absorption coefficient shall be determined from the following:

$$A = \frac{W_2 - W_1}{W_2} \times 100$$

where

A = absorption co-efficient (percent),
W_2 = mass after immersion, and
W_1 = mass before immersion.

ANNEX C

(*Clause* 10.5)

OVEN TEST FOR CRACKING OR CRAZING

C-1 PROCEDURE

C-1.1 After 10 days in a circulating air-oven maintained at 80 ± 2°C the test pieces shall be visually inspected for cracks or crazing.

ANNEX D

(*Clause* 10.6)

MEASUREMENT OF GEL COAT THICKNESS

D-1 PROCEDURE

D-1.1 The thickness of the gel coat shall be measured by cutting a test section from the area to be measured and sandpapering the edge to section, until smooth. A suitable measuring device shall be kept across the edge, perpendicular to the place of the gel coat and the thickness of the gel coat shall be measured with the aid of a reading glass, if needed, for conformity with **10.6**.

ANNEX E

(*Clause* 10.7)

DETERMINATION OF GLASS CONTENT

E-1 PROCEDURE

E-1.1 The glass content in the laminate shall be determined using the following procedure. The specimen is first weighed on an analytical balance in a previously weighed, ignited crucible. The specimen is placed in the furnace at a temperature not exceeding 340°C. The temperature of the furnace is raised to 565 ± 28°C, at a rate that will not cause blowing. The specimen and crucible are then ignited at this maximum temperature to constant mass (2 — 6 h depending on the thickness) and allowed to cool in a desiccator. The loss in mass shall be determined by weighing the residue.

$$\text{Glass content, mass percent} = \frac{W_0 - W_1}{W_0} \times 100$$

where

W_1 = loss in mass, and
W_0 = original mass.

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